HYDROGEN-OXYGEN ELECTROLYTIC REGENERATIVE FUEL CELLS

Prepared for

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1. INTRODUCTION

This report briefly reviews the progress made on the development of a regenerative hydrogen/oxygen fuel cell (NAS Contract 3-2781) during the period 26 April through 26 May, 1964. Several test series were carried out on the assembly. Additional data on the permeability of hydrogen through asbestos matrices was also obtained.

2. TECHNICAL DISCUSSION

2.1 Cell Studies

As a result of the two teflon gasket failures reported in last month's progress report, a new series of tests was initiated to evaluate performance with rubber gaskets and different grades of asbestos. In addition, an assembly check list procedure was initiated to insure closer quality control and to maintain a record of the individual steps taken during the assembly and checkout of the cell stack.

The first test run made during this reporting period, (Run No. 10) was made using viton rubber gaskets. Unfortunately, these gaskets were about 0.010 inch thicker than desired, i.e., 0.043 inch. This required a modification of the asbestos matrix separator bed in order to maintain an approximate 7/4 compression ratio on the asbestos. The modification consisted of the addition of a third layer of asbestos, 0.020 inch nominal thickness, between the standard two layers of 0.035 inch nominal material. Other modifications made on this run were as follows:

1. Electrolyte/asbestos weight ratio increased to 0.73 from 0.70.
2. Cell evacuated to ≈ 20 inches Hg (gauge) prior to purge.
3. Cell charged for a few minutes at ambient pressure prior to starting run.

Results of Run No. 10 were quite encouraging in that the cell ran for about 36 hours prior to an apparent cell degradation problem. Cell performance was not, however, typical of that achieved during prior testing. Initially, this was attributed to electrode flooding caused by the higher electrolyte to asbestos ratio used. However, subsequent drying of the electrode/asbestos matrix by electrolysis did not significantly improve performance. Analysis of the permeability data plus data from the following run indicate that the 0.020 inch asbestos material used causes concentration polarization, due to an apparent limiting of the mobility of the electrolyte.

Near the end of the 36 hour period, cell performance began to deteriorate rapidly on discharge. A rapid decline in cell voltage indicated that a cell reversal had occurred. Inasmuch as such a cell reversal could result in bulk gas mixing and drying out of the asbestos of the reversed cell, it was decided to terminate this run. Upon disassembly of the cell, no apparent cause for the cell reversal was determined.

Since there are but three pertinent causes for cell reversal in the regenerative H_2/O_2 cell, i.e., poor electrodes, electrolyte contamination or gas blockage, each of these was evaluated. No gas port blockage could be determined. The electrolyte was re-analyzed and found to be well within tolerance. This left electrode contamination as the most likely culprit. Therefore, a new set of electrodes was prepared.

Run 11 was made using the new set of electrodes. Due to a vendor problem in obtaining suitable viton gaskets, it was decided to use silicone rubber gaskets. Here again, the inability of the gasket material supplier to hold a desirable tolerance caused a change in assembly procedure. This time, the gaskets were about 0.048 inches thick, again causing a modification in the asbestos matrix used. In order to maintain an approximate 7/4 compression ratio, two layers of 0.020 material and one of the 0.035 material were used. As indicated

in the foregoing, this electrolyte matrix proved to be an abnormal impedance to electrolyte flow.

During the initial cycle of Run 11, an unusual variation of the pressure differential in the cell was noted. It appeared that the pressure differential was a function of the charge or discharge rate rather than a function of time. This was indicative of an internal leak into the supposedly sealed stearic acid container compartments. After 1 cycle, the cell tanks were disassembled and the leakage confirmed. The plug sealing the stearic acid chamber compartment was removed, and the cell reassembled. (Note--stearic acid had been removed from all compartments prior to Run 10.). This process eliminated the pressure variation and the run was continued.

Cell performance was poor during this run on both charge and discharge. By introducing gases from external sources and discharging the cell, thus in effect adding water, the cell performance during charge could be improved slightly. This indicated that electrolyte migration from the asbestos to the electrodes was being impeded. After about 10 hours of operation with little significant improvement, the run was terminated.

Run 12 was initiated using silicone gaskets from the same batch as Run 11. Instead of using the 0.020 inch material, however, two layers of 0.035 material were used. At the standard cell stack torque of 40 inch pounds, however, these materials did not give a 7/4 compression ratio on the asbestos. The run was started at this torque level for the first charge cycle. It was noted that a minor pressure differential built up then decreased to zero. This indicated that the cell stack was leaking. In addition, upon trying to discharge the cell, very poor performance was observed.

The cell tanks were vented, disassembled, and the stack leak checked. It was readily apparent that at the higher state of charge, i.e., when less water was in the asbestos, the cell would leak across the stack. By further compressing the stack to 75 inch pounds, i.e., increasing the asbestos compression, the leak was stopped.

Although the leak was stopped, subsequent performance did not improve upon reassembly. Preliminary discharge tests indicated that a cell reversal had occurred. Upon disassembly, without prior purge with nitrogen, two cells were found to have reversed.

2.2 Permeability Studies

Asbestos permeability studies are being continued, with emphasis being placed upon improvement in repeatability of results. In addition to the standard commercial grades of asbestos being tested, a roll of 0.060 electrolytic grade asbestos has been obtained for evaluation.

3. PLANS FOR JUNE

Single cell tests will be made on the electrodes of the cells found to be reversed in Run 12 in order to determine the cause of the reversals. Upon completion of these tests, a new cell stack will be assembled, and the 48 hour test evaluation started. In addition, gas permeability through the asbestos matrix materials will be continued.